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The Effects of Shellfish Consumption Frequency for Human Health

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Abstract

Depending on the world population, the importance of water resources and the consumption of aquatic organisms as a food source are increasing day by day. The presence of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are involved in critically important biochemical and physiological processes in the body, emphasizes the importance of seafood consumption. Shellfish are low in calories but rich in protein and omega-3 fatty acids. They also contain high amounts of many micronutrients, including iron, zinc, magnesium and B12. Consuming shellfish regularly can boost immunity, aid weight loss, and support brain and heart health. However, shellfish is one of the common food allergens, and some species may contain contaminants and heavy metals. Aquatic products poisoning occurs with the consumption of unhealthy seafood or fish containing toxins. Symptoms cause severe and fatal poisoning in consumers, depending on the presence and concentration of the toxin. To prevent food poisoning, information on the growing conditions of the species should be provided and regularly inspected for toxins (heavy metal poisoning and allergic reactions).

Keywords: Shellfish, health, diet, consumption

1. Introduction

Shellfish include shrimp, crayfish, crab, lobster, oysters, scallops, and mussels. Shellfish have been prepared in different ways and consumed for many years. Shellfish are animals that live in water and have a shell or shell-like exterior. They can be divided into two groups as crustaceans and mollusks. Crustaceans include shrimp, crayfish, crab, and lobster; oysters, scallops and mussels are examples of mollusks. Most shellfish live in saltwater, but the name also refers to species found in freshwater [1].

Shellfish are an important component of global seafood production. Shellfish contain a variety of vitamins and minerals, especially digestible proteins, and essential amino acids. It is among the foods that provide health benefits to consumers [2]. Although shellfish are generally a safe food source for consumption, they sometimes pose health risks due to their exposure to various habitats, the filtering of water by organisms such as oysters and mussels, and unhealthy agricultural practices.

Environmental hazards include factors that cause negative effects on living things and even cause death, especially pathogenic organisms and biotoxins. Appropriate preventive measures should be taken at the various stages of harvest, processing, storage, distribution, and consumption. For this reason, control measures are very important to protect the nutritional value and health benefits of shell products and consumer safety regarding the products [3, 4].

2. Some aquatic species with an economic aspect

Aquaculture can be obtained almost anywhere there is water. Especially in regions where temperate climate is dominant, the diversity of these products is increasing. While only fish and its derivatives are consumed in some places, less preferred foods such as octopus and even plants grown in the sea are consumed in some cuisines of the world.

Aquaculture means the products obtained from the species such as fish, mollusks, crustaceans, mammals, reptiles, sponges, and aquatic plants produced naturally or artificially in seas, inland waters and artificial pools, dams, ponds, fisheries, and fishing facilities. Some of the economical shellfish species found in the seas are explained below [5].

Gastropods; Sea snail (*Rapana thomasiana*, Gross 1861) (**Figure 1**) [6].

Cephalopods; Octopus (*Octopus vulgaris*, Linnaeus 1758, **Figure 2**), The European Squid (*Loligo vulgaris*, Lamarck 1798), The Common Cuttlefish (*Sepia officinalis*, Linnaeus 1758) [7].

Bivalves; Mussel (*Mytilus galloprovincialis*), Oyster (*Ostrea edulis*), Akivades (*Tapes decussatus*), Kidonia (*Venus verrucosa*), Sand mussel (*Venus gallina*) [8, 9].

Crustaceans; Shrimp (*Penaeus keathurus*), Insect (*Palinurus vulgaris*), Crayfish (*Astacus leptodactylus*), Spiny crab (*Maia squinada*), Blue crab (*Callinectes sapidus*), Lobster (*Homarus gammarus*) [10–13].

2.1 *Mytilus galloprovincialis*

The black mussel, whose scientific name is *Mytilus galloprovincialis* (Lamarck, 1819), is also known as the Mediterranean Mussel. The Black mussel is in the Bivalvia (bivalves) class of the Mollusca (**Figure 3**).

Mussels are creatures consisting of bivalves, interlocked with each other with a very strong musculature, triangular in front, ovoid in the back and bilateral



Figure 1.
Rapana thomasiana, Gross 1861 [6].



Figure 2.
Octopus vulgaris, Linnaeus 1758 [7].



Figure 3.
Mytilus galloprovincialis, Lamarck, 1819 [8].

symmetry. The shell consists of anterior margin, posterior margin, ventral margin, and dorsal margin. The leading margin is very brief and the shells interlock here. The outside of the shell is in diverse trace of purple-black and brown, and the inside is of pearl shine. There are growth lines on the shells that draw small elliptical circles starting from the junction of the shells. Although the common height of this species is 5–8 cm, it can reach a maximum of 10–11 cm. The temperature and salinity of the region have an important effect on the development of mussels, and the most delicious period of mussel meat is from autumn to the beginning of spring. Since bivalve mollusks feed by filtering water, they accumulate microbiological, chemical, or natural toxins in polluted aquatic environments, therefore, they must be given for consumption in a controlled manner. In aquatic environments with increased pollution, aquaculture rather than hunting is the most reliable way to enable controlled production [14–16].

Black mussel is a popular seafood that is consumed with admiration all over the world, especially in European and Pacific countries. These creatures, which live in the coastal regions of the marine ecosystem, can be obtained from nature by hunting or they can be produced through culture. Mussels, which have as valuable and quality protein as fish meat, can be consumed in various ways such as stuffed mussels, pan and brine. Mussels, which have a short shelf life, should be prepared, and consumed as soon as possible or stored by paying attention to storage conditions [16].

2.2 *Penaeus keathurus*

Shrimp are ten-legged arthropods that live in fresh and salt water. Freshwater shrimps are mostly common in tropical regions. Their size is varying cylindrical body between 1 and 30 cm. Its body is covered with an armor made of calcium carbonate. These creatures, whose bodies are jointed, swim backwards by waving

their wide, fin-like tails. It has five pairs of legs and at least two of them have claws. The antennae, which are two pairs, are very long and bifurcated. At least one of these forks bends back, allowing the shrimp to retract into the crevices and signal danger from behind. The most obvious reaction of the shrimp in the face of danger is to try to protect itself with a sudden twist. Their body color can change to suit their environment. There are large-clawed predators that feed on small fish, as well as scavengers that feed on food particles in the sand. In some species, there are brush-like bristles on their claws to easily collect food particles (**Figure 4**) [17].

Some types are less tasty than others and some types are not consumed. It is farmed in countries such as America, Japan, Thailand, and Taiwan. Consumption in the USA is higher than in other countries. Since shrimp species found in cold waters grow slowly, their meat is more delicious. Depending on the species, their flesh can be firm and transparent, pink, yellow, gray, brown and red. The flesh color, which is transparent when cooked, takes a dull and pinkish color. One of the commercially important species is the deep-water shrimp (*Pandalus borealis*). The other is the large black shrimp (*Penaeus monodon*). Since shrimp species spoil easily after hunting and melanosis (black spots) form on their meat, they should be cooled immediately, and their heads should be cut off. The most expensive of the shrimp species are the largest ones. If fresh shrimp are to be bought, their bodies should be firm, not sticky, and soft, their bodies should not be separated from their shells and their heads should not be surrounded by black spots. It can be stored fresh for about 2 days in the refrigerator and frozen for 1 month [18].

2.3 *Loligo vulgaris*

Squid, like other cephalopods, has a prominent head, bilaterally symmetrical structure, mantle, and arms. The substance called melanin in it is the same pigment that tans human skin. Its eyes are in the middle of its head and body. It has 8 arms surrounding the mouth with a sharp, parrot-like beak, and two distinctly longer tentacles. Most of the squid is formed by a thick muscle cover called the mantle, which protects the internal organs and allows the squid to move through the water by spraying strongly with water. It compresses the water in the mantle and sprays the water quickly from the section also called siphon, allowing it to swim backwards. Thanks to its funnel-shaped structure that creates a jet effect, squid can accelerate in water more than 3 times the speed of Olympic swimmers (**Figure 5**) [19].



Figure 4.
Venus verrucosa, Linnaeus, 1758 [9].



Figure 5.
Penaeus keathurus, Forskål, 1775 [10].

Squid, which is the lowest calorie seafood product, contains protein, very little fat, phosphorus, magnesium, and calcium. It also contains vitamins B2, B3 and B12. To clean the squid, the internal organs must be removed by pulling from the tail. By holding the tip of the squid, it is necessary to quickly pull and clean the outer skin. After cleaning the outer skin and internal organs, the transparent bone in the middle of the squid should also be removed and the squid should be washed well. The cleaned squid is offered for sale in the form of rings and frozen. Fresh squid can be stored in the refrigerator for 1–2 days. Frozen squid can be stored in the freezer for 1–2 months [20].

2.4 *Ostrea edulis*

Ostrea edulis (Linnaeus, 1758) is a bivalve mollusk with very tasty meat and cultivated. It consists of two circular shaped shells and these shells are connected to each other by a structure called ligament. It lives in offshore sandy, pebbly, or rocky areas in all our seas. It is not found in brackish waters. It feeds on plankton and suspends organic matter. They are oysters evaluated as fresh. The peel is quite light, thick, and oval. Yellowish-brown, right bark is flat, straight, and covered with inconspicuous radial folds. The left shell is in the form of a convex cube and its edges are serrated. The shell surface is irregularly indented. Its maximum length is 12 cm. It has a characteristic shellfish odor. There are no irritating odors (ammonia smell, etc.) (**Figure 6**) [21].

The shells do not open with manual intervention, but they can be opened by cutting the ligament with the help of a cutter. When it first reaches sexual maturity, the gonad normally develops like a male and gives off sperm. After the gonad releases the sperm, it passes into the female stage and produces eggs instead of sperm. This



Figure 6.
Callinectes sapidus, Rathbun, 1896 [11, 12].

continues a regular basis throughout his life. The formation of pearls is completed because of the combination of sand and similar materials in the seas, where many kinds of creatures can live, by entering the oyster shells and combining with the mother-of-pearl secretions. Fresh products can be stored in cold stores between 0°C and + 4°C between pieces of ice. Frozen products that have been frozen at –40°C and will wait for a long time should be stored at a temperature of –22°C to –18°C in the center. The product should not be kept together with substances that emit a foreign odor or that will pollute it. Meat texture should be fresh, firm, and unique, natural color. It is served as fresh raw or cooked with various sauces. It is recommended to boil it with its peel during cooking. It is offered for sale as cooked canned or smoked oysters [22].

2.5 *Astacus leptodactylus*

Although the Eastern European crayfish (*Astacus leptodactylus*) was considered an important commercial product (a luxury food item) in the world after the 1830s, it was only used in World War II in Turkey. After the World War II, it became one of the important export products among aquaculture products. While the total crayfish production was 500 tons in 1979, this value was 6500 tons in 1982, and after 1986, it gradually decreased due to the occurrence of crayfish plague (*Aphanomyces astaci*), overfishing and environmental pollution. Today, total crayfish production (1894 tons, 2002 data) is around 15% of the 1980s. About 600 crayfish species are found naturally in other continents except Africa and Antarctica. In addition, crayfish migrate from their original environment to other environments, intensively, naturally (with migration or currents); They were transported by chance (by ships' ballast waters, channels, being used in traps for catching fish, escaping from the environments where they were kept under control, being carried by predators or people unknowingly) or consciously by people (keeping them as a hobby in aquariums, production and aquaculture, control of aquatic plants). The most important and common factor in the transportation of crayfish from one environment to another is the desire of entrepreneurs to earn economic income from these creatures (Figure 7) [23].

The trunk is divided into two parts, the thorax, and the abdomen. The chest is covered with a hard and prominent shell. The skeleton-shell is outside. The shell is immobile and hard except for the articular parts. The joints are soft and thin, and their structure is also different. There are 4 pairs (8 pieces) of feet for walking in the chest part. The abdomen consists of 6 segments. Freshwater crayfish are smaller



Figure 7.
Astacus leptodactylus, Eschscholtz, 1823 [13].

and red in color. Those that live in salt water are also larger and lighter in color. They are voracious and aggressive species. It is found in rivers, lakes, streams, and ponds. In many countries, the consumption of crayfish with pleasure and the increase in its economic value day by day has accelerated the production of this product under cultural conditions. It is cultivated on farms in Europe, especially in South America. There are 300 different types available. Some species are distinguished by the red or white color of their claws. Their shells are red, brown, and purple in color. It has lean and delicious pink, white flesh. Crayfish normally have a heavy, wobbly gait. Walking is forward through the legs. However, their swimming is backwards. Crayfish generally like flowing and abundant calcareous waters. It enables the development of limestone crusts. They are rarely found in acidic waters. It can be sold live, cooked, frozen, or canned. If cooked, those with firm skins and complete claws should be chosen. It must be cleaned before cooking. It contains very little meat. Live crayfish can be stored wrapped in a damp cloth for 12 hours in the refrigerator, 1–2 days in the refrigerator when cooked, and 1–2 months frozen [24].

3. The importance of nutrition with shellfish

Shellfish are rich in low-calorie lean protein, essential oils, and micronutrients. Most of the fats found in shellfish are in the form of omega-3 fatty acids, which have benefits for improving brain and heart health. Shellfish are rich in iron, zinc, magnesium, and vitamin B12, all of which play important roles in our bodies. For example, 85 g oysters have almost 100% of the daily value for zinc. Shellfish are most nutritious when steamed. Fried shellfish may contain ingredients such as additional calories, refined carbohydrates, added salt. With its impressive nutritional content, shellfish has low calories. This makes them excellent foods to eat while trying to lose weight. Protein-rich foods can help you lose or maintain weight by preventing you from consuming calories. Due to its omega-3 fatty acid content, it can lead to a greater feeling of satiety than fish and may help to lose weight faster than other high-protein foods. A study of overweight adults found that those who consumed more omega-3 fatty acids on a calorie-restricted diet felt significantly fuller after meals than those who consumed less omega-3 on the same diet [25]. In order to obtain the maximum benefit from shellfish as food, it is extremely important that the environmental conditions in which the consumed products are supplied are healthy, as well as the depuration of the products by the companies and the storage conditions of the packaged products until the expiry date without breaking the cold chain.

Shellfish have microelements that can improve the health of heart, including omega-3 fatty acid and vitamin B12. Studies have shown that getting omega-3 fatty acid from fish and shellfish is linked to a lower risk of heart disease. This is probably because omega-3 have anti-inflammatory effects. In a study of 18,244 healthy men in China, those who ate more than 200 grams of omega-3-rich shellfish per week were 59% less likely to die from a heart attack than those who ate less than 50 gram per week. Inadequate B12 intake has also been linked to high blood levels of homocysteine, a protein that may increase your risk of heart disease. Therefore, foods rich in vitamin B12 may protect against heart disease. Studies have identified insufficient B12 and omega-3 levels as risk factors for problems with brain development in children and healthy brain function in adults. Some research also suggests that vitamin B12 and omega-3 fatty acid may improve each other's activities to improve brain health. In a study of 168 adults with mild mental disorders it was found that B vitamins slowed the progression of brain problems in those with lower levels of omega-3 fatty acids compared to those with low levels. Shellfish contain zinc, which

| Type | Calories | Protein | Fat |
|----------|----------|----------|------------|
| Shrimp | 72 | 17 grams | 0.43 grams |
| Crayfish | 65 | 14 grams | 0.81 grams |
| Crab | 74 | 15 grams | 0.92 grams |
| Lobster | 64 | 14 grams | 0.64 grams |
| Clams | 73 | 12 grams | 0.82 grams |
| Scallops | 59 | 10 grams | 0.42 grams |
| Oysters | 69 | 8 grams | 2 grams |
| Mussels | 73 | 10 grams | 1.9 grams |

Table 1.
Nutrition facts of 85-gram of different types of shellfish (<https://fdc.nal.usda.gov/ndb/>).

strengthens the immune system. This mineral is necessary to strengthen the cells that make up the immune defense of our body. It also acts as an antioxidant, protecting against damage caused by inflammation. A study of 62 healthy adults over the age of 90 showed that zinc deficiency reduced the activity of certain immune cells. Shellfish are full of protein and healthy fats that can aid weight loss. It is also rich in omega-3 fatty acids, vitamin B12 and zinc, which support a healthy brain, heart, and immune system (**Table 1**) [26].

4. Negative effects of excessive consumption of shellfish

Although shellfish are highly nutritious, they have some disadvantages when consumed excessively. Shellfish have the potential to accumulate heavy metals such as mercury or cadmium from the environment. The accumulation of these compounds in our bodies can lead to organ damage and other health problems. One study showed that shellfish in some regions may contain cadmium at twice the recommended daily dose. The Food and Drug Administration recommends that adults eat 85–140 grams of low-mercury fish twice a week. If the number of shellfish we eat in a week is equal to or less than this, there is no danger in terms of heavy metals. Consuming shellfish obtained from waters where polluting factors prevail causes many food-borne diseases. Mollusks such as oysters and mussels accounted for more than 45% of seafood-related foodborne illness cases in the United States America (USA) from 1973 to 2006. Food poisoning from shellfish can be caused by bacteria, viruses, or parasites in the environment. Pathogens thrive in raw shellfish that are not properly refrigerated. Therefore, obtaining shellfish from clean waters, storing, and cooking them properly is the most effective way to prevent foodborne illness. Pregnant and nursing mothers, older adults, and people with compromised immune systems should avoid raw or improperly prepared shellfish [27, 28].

Shellfish is one of the top eight food allergens in the USA. Shellfish allergy typically develops in adulthood but can also occur in childhood. Symptoms of an allergic reaction to shellfish include vomiting and diarrhea, stomach pain and cramps, swelling of the throat, tongue or lips, hives, shortness of breath. In some cases, people with a shellfish allergy may experience a life-threatening anaphylactic shock that requires immediate treatment. Shellfish can accumulate different levels of heavy metals that can build up in your body and cause health problems. Diagnosing allergies to shellfish can be difficult and complex. Symptoms can vary from person to person, depending on metabolism, and may not always give the same reaction. People with shellfish allergies may not need to eat only these products to develop a reaction. A reaction may also occur on contact with cooked shellfish. Allergic

reactions to these creatures can also affect the skin, respiratory, digestive, and circulatory systems. Although these allergies are not very common in adults, they can occur at any age. In the case of this type of food allergy situation, it is important to consult an allergist who can determine what tests need to be done after diagnosis, decide whether it is an allergy, and advise patients on how to manage exposure and symptoms [29].

Allergies to shellfish occur when the immune system opposes the proteins found in these animals. When these proteins enter the body of individuals with allergies, the immune system overreacts and tries hard to fight against the antigens it sees as foreign. Some of these reactions occur due to the release of histamine, which causes allergy symptoms. Therefore, antihistamines can give effective results in such an allergic reaction. For people whose shellfish allergy is confirmed by further testing, the only treatment is to avoid these creatures altogether. In the event of exposure or a serious reaction, every second counts. Detecting the reaction early and administering epinephrine quickly can prevent worsening of the condition and possible death [30, 31].

History is very important for diagnosis in patients with suspected Shellfish allergy. The patient's history is necessary both for determining the severity of the disease and for planning diagnostic procedures. Therefore, before going to the doctor, review your complaints in detail. In general, those with suspected allergies,

- Skin prick tests,
- Determination of fish-specific IgE in serum,
- If necessary, loading tests are performed with foods that are thought to be responsible. In recent years, component-based diagnosis method has also been applied to make a more accurate diagnosis and obtain information about the course [32].

5. Conclusion

Shellfish, which can be divided into crustaceans and mollusks, are full of lean protein, healthy fats, and many beneficial microelements. They can aid weight loss, boost immunity, and improve brain and heart health. However, shellfish may contain heavy metals. May cause foodborne illness and allergic reactions. However, shellfish are delicious foods that support a balanced diet. Shellfish are among healthy foods when consumed in moderation.

Shellfish is one of allergens covered by the labeling of the FALCPA (Food Allergen Labeling and Consumer Protection Act). This labeling must appear on packaged food products containing shellfish sold in the USA. The presence of shellfish in the product should be indicated on the packaging. Shellfish is rarely hidden in consumption. Shellfish may be found in fish stocks, flavoring, surimi and sushi. Anyone with a food allergy should read ingredient labels and take precautions. Doctors can point you to helpful resources that can help you plan your meals, such as patient support groups and registered dietitians.

Conflict of interest

No conflict of interest.

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